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MIL-A-46100D(MR)
16 May 1988
SUPERSEDING
MIL-A-46100C
13 June 1983
AMENDMENT 2
20 October 1986

MILITARY SPECIFICATION

# ARMOR PLATE, STEEL, WROUGHT, HIGH-HARDNESS

This specification is approved for use within the Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers quenched and tempered high-hardness wrought steel armor plate for lightweight armor applications for recommended thickness up to 2 inches inclusive (see 6.1 and 6.3).

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified (see 6.2), the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation, form a part of this specification to the extent specified herein.

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage
MIL-STD-163 - Steel Mill Products Preparation for Shipment and Storage
MIL-STD-367 - Armor Test Data Reporting
MIL-STD-1185 - Welding High Hardness Armor

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

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Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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AMSC No. A4388 /FSC 9515/

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2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this specification to the extent specified herein.

USATECOM TOP 2-2-710 - Ballistic Tests of Armor Materials
QSTAG 335 - Certification of Personnel for Ultrasonic Inspection

(Application for copies should be addressed to the Director, Defense Technical Information Center, Attn: DDR, Cameron Station, Alexandria, VA 22314)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DODISS and the supplement thereto, if applicable.

ASTM

ASTM A578 - Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications
ASTM A751 - Methods, Practices, and Definitions for Chemical Analysis of Steel Products
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E23 - Notched Bar Impact Testing of Metallic Materials
ASTM E109 - Dry Powder Magnetic Particle Inspection
ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials

(Application for copies should be addressed to ASTM, 1916 Race Street, Philadelphia, PA 19103.)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order (see 4.2.1.1.2, 6.2, 6.4, and 6.9), a sample or samples of the specified item shall be made available to the contracting officer or his authorized representative for approval in accordance with 4.2.1.1. The approval of the first article samples authorizes the commencement of shipment but does not relieve the supplier of responsiblity for compliance with all applicable provisions of this specification. The first article samples and test plates shall be manufactured by the process proposed for use on production armor. The manufacturer's declared chemical analysis must be submitted to the contracting agency and to the ballistic test agency. The ballistic test agency will record the first article ballistic test plates submitted, showing the dates tested. Requests from the procuring activity to the ballistic test agency as

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to prior conformance with first article tests must be accompained by copies of the first article test firing records. Any deviation(s) noticed by the ballistic agency will be brought to the attention of the contracting activity and to the manufacturer.

3.1.1 First time producer. First time producers wishing to qualify to this specification should follow the instructions of 6.7.

TABLE I. Chemical composition (product analysis). 1/ 5/

| Element | Maximum Range Percent | Maximum Limit Percent |
|---|---|---|
| CARBON | 0.10 | 0.32 |
| MANGANESE: Up to 1.00% incl | 0.30 | - |
| Over 1.00% | 0.40 | - |
| PHOSPHORUS | - | 0.020 2/ |
| SULFUR | - | 0.010 2/ |
| SILICON: Up to 0.60% incl | 0.20 | - |
| Over 0.60% to 1.00% incl | 0.30 | - |
| NICKEL | 0.50 | - |
| CHROMIUM: Up to 1.25% incl | 0.30 | - |
| Over 1.25% | 0.40 | - |
| MOLYBDENUM: Up to 0.20% incl | 0.07 | - |
| Over 0.20% | 0.15 | |
| VANADIUM | 0.15 | - |
| BORON | - | - 3/ |
| COPPER | - | 0.25 4/ |
| TITANIUM | - | 0.10 4/ |
| ZIRCONIUM | - | 0.10 4/ |
| ALUMINUM | - | 0.10 4/ |
| LEAD | - | 0.01 4/ |
| TIN | - | 0.02 4/ |
| ANTIMONY | - | 0.02 4/ |
| ARSENIC | - | 0.02 4/ |

1/ This table lists the maximum range for elements of the manufacturer's established chemical composition.

2/ Phosphorus and sulfur should be controlled to the lowest attainable levels but in no case should the combined phosphorus and sulfur content exceed 0.025 percent.

3/ When the amount of boron is specified in the alloy, its content so determined by heat analysis shall not exceed 0.003%.

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4/ When the amount of an element is less than 0.02% the analysis may be reported as 0.02%.

5/ Elements not listed in table, but intentionally added, shall be reported.

3.2 Acceptance requirements.

3.2.1 Chemical composition. The product produced to this specification shall meet the analysis of table I unless otherwise agreed upon between the steel supplier and the purchaser. All limits as specified in table I (including any deviations negotiated) shall be submitted in advance to the purchaser. The purchaser may establish and submit separate limits for each thickness of plate to be furnished (see 6.5). A statement showing the heat analysis of each melt and one product analysis of each lot and complete details of the heat treatment of each lot shall be furnished for the files of the purchaser at no cost. All elements of the chemical composition specified in table I shall be shown in the statement. When specified in the contract or order, armor material test reports shall be prepared in accordance with MIL-STD-367 to report the chemical composition range established by the producer and the chemical analysis of the material submitted (see 6.2.2 and 6.6).

3.2.2 Heat treatment. All plates in each lot, including samples, shall receive the same heat treatment except for such variations in tempering temperature as may be necessary to produce the prescribed hardness. Unless otherwise specified, local or general heating shall not be performed after the final heat treating operation (see 6.2). This does not include preheating for welding or flame cutting, as long as the tempering temperature is not exceeded. Unless otherwise specified (see 6.2) all plates shall be tempered for a minimum of 30 minutes after the centerline of the plate thickness has reached a temperature of at least 350°F, or shall be tempered for a minimum of one hour for each inch of thickness after the plate surface has reached a temperature of at least 350°F. For plates under one inch thick the tempering process shall be carried out according to the time schedule listed below, after the plate surface has reached a minimum temperature of 350°F:

| | |
|---|---|
| 1.00 inch | 1 hour minimum |
| 0.75 inch | 3/4 hour minimum |
| 0.50 inch | 1/2 hour minimum |
| 0.25 inch | 1/2 hour minimum |

The tempering operation should be done as soon as possible after quenching. It is recommended that the delay after quenching be no greater than 24 hours.

3.2.3 Condition. Unless otherwise specified (see 6.2), plates shall be in the as-heat treated condition; surfaces shall not be pickled.

3.2.4 Mechanical properties.

3.2.4.1 Hardness. The surface hardness of each plate, including first article samples, shall be within the range of HB 477 - HB 534. The diameters of Brinell hardness impressions on any individual plate shall not vary by more than 0.15 mm (see 4.6.2).

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3.2.4.2 Impact resistance. The minimum Charpy V-notch impact resistance requirement of the armor plate shall be as shown in table II. The Charpy V-notch specimens shall be obtained in both the TL orientation (i.e., transverse to the major direction of rolling with the notch perpendicular to the plate surface so that the crack will propagate in the longitudinal direction) and the LT orientation (i.e., parallel to the major direction of rolling).

TABLE II. Minimum Charpy V-notch impact resistance requirements at -40° ± 2°F.

| Specimen orientation | Impact resistance for standard depth specimens (Average of 2 or more specimens), ft. lbs. | | | |
|---|---|---|---|---|
| | Standard width | 3/4 width | 1/2 width | 1/4 width |
| Transverse (T-L) | 10.0 | 7.5 | 5.0 | 2.5 |
| Longitudinal (L-T) | 12.0 | 9.0 | 6.0 | 3.0 |

3.2.5 Bend test. All bend test samples from that lot shall be capable of being bent to the requirements below without cracking as determined by either penetrant inspection per MIL-STD-6866 or magnetic particle inspection per MIL-STD-1949. Two bend test samples shall be tested in the transverse direction per ASTM E290, transverse bend test, at room temperature through an included angle of 90° (unrestrained) to the inside radii shown below. After bending, samples shall be free of cracks as determined by either penetrant inspection per MIL-STD-6866 or magnetic particle inspection per MIL-STD-1949.

| PLATE THICKNESS (T) | INSIDE RADIUS |
|---|---|
| 1/8 to 5/16 | 4T |
| Over 5/16 to 1/2 | 6T |
| Over 1/2 to 3/4 | 8T |
| Over 3/4 to 1 | 10T |
| Over 1 to 2 | 12T |

NOTE: The bend test on material thicker than 1/2 inch shall be negotiated between the steel supplier and contractor if bending is required. Dimensions for thickness over 1/2 inch are listed for information purposes only.

3.2.6 Ballistic requirements. Ballistic requirements shall be in accordance with the appendix of this specification.

3.2.7 Dimensions and tolerances.

3.2.7.1 Dimensions. Plates shall comply with the dimensions specified in the applicable drawings or in the contract or order (see 6.2).

3.2.7.2 Thickness. The thickness tolerance of each plate, after final treatment, shall be in accordance with table III for the thickness specified.

3.2.7.3 Flatness. Unless otherwise specified in the contract or order, the flatness tolerance of each plate shall be within the requirements specified in

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table IV. Tighter tolerance requirements may be specified in the contract or order and shall be as agreed upon between the contractor and the procuring activity.

3.2.7.4 Waviness. Unless otherwise specified in the contract or order, the waviness tolerance of each plate shall be within the requirements of table V.

TABLE III. Thickness tolerances for ordered thickness 1/, inches (over and under) 2/.

| Specified Thickness Inches | To 60" | Tolerances over and under ordered thickness for widths given: 60" to 72" excl. | 72 to 84" excl. | 84 to 96" excl. | 96 to 108" excl. | 108 to 120" excl. | 120 to 132" excl. | 132 to 144" incl. |
|---|---|---|---|---|---|---|---|---|
| 1/8 | 2/ | .016 | .016 | .019 | .019 | .023 | ---- | ---- |
| 3/16 | 2/ | .016 | .016 | .019 | .019 | .023 | ---- | ---- |
| 1/4 | 2/ | .016 | .016 | .019 | .019 | .023 | ---- | ---- |
| 5/16 | 2/ | .016 | .019 | .019 | .019 | .023 | .026 | ---- |
| 3/8 | 2/ | .016 | .019 | .019 | .023 | .023 | .026 | ---- |
| 7/16 | 2/ | .016 | .019 | .019 | .023 | .026 | .026 | .031 |
| 1/2 | 2/ | .016 | .019 | .019 | .023 | .026 | .026 | .031 |
| 9/16 | 2/ | .019 | .019 | .019 | .023 | .026 | .031 | .031 |
| 5/8 | 2/ | .019 | .019 | .019 | .023 | .026 | .031 | .031 |
| 11/16 | 2/ | .019 | .019 | .019 | .023 | .026 | .031 | .031 |
| 3/4 | 2/ | .019 | .019 | .023 | .023 | .026 | .031 | .039 |
| 13/16 | 2/ | .023 | .023 | .023 | .026 | .031 | .031 | .039 |
| 7/8 | 2/ | .023 | .023 | .026 | .026 | .031 | .031 | .039 |
| 15/16 | 2/ | .023 | .023 | .026 | .026 | .031 | .036 | .043 |
| 1 | 2/ | .026 | .026 | .026 | .026 | .031 | .036 | .043 |
| 1-1/16 | 2/ | .026 | .026 | .026 | .031 | .031 | .036 | .043 |
| 1-1/8 | 2/ | .026 | .026 | .026 | .031 | .031 | .039 | .043 |
| 1-3/16 | 2/ | .031 | .031 | .031 | .031 | .036 | .043 | .048 |
| 1-1/4 | 2/ | .031 | .031 | .031 | .036 | .036 | .043 | .048 |
| 1-5/16 | 2/ | .031 | .031 | .031 | .036 | .036 | .043 | .053 |
| 1-3/8 | 2/ | .031 | .031 | .031 | .036 | .039 | .048 | .053 |
| 1-7/16 | 2/ | .036 | .036 | .036 | .036 | .043 | .048 | .058 |
| 1-1/2 | 2/ | .036 | .036 | .036 | .039 | .043 | .048 | .058 |
| 1-9/16 | 2/ | .036 | .036 | .036 | .039 | .043 | .058 | .058 |
| 1-5/8 | 2/ | .036 | .036 | .036 | .043 | .048 | .058 | .063 |
| 1-11/16 | 2/ | .039 | .039 | .039 | .043 | .048 | .058 | .063 |
| 1-3/4 | 2/ | .039 | .039 | .039 | .043 | .048 | .058 | .068 |
| 1-13/16 | 2/ | .043 | .043 | .043 | .048 | .053 | .058 | .068 |
| 1-7/8 | 2/ | .043 | .043 | .043 | .048 | .053 | .063 | .068 |
| 1-15/16 | 2/ | .043 | .043 | .043 | .048 | .053 | .063 | .076 |
| 2 | 2/ | .043 | .043 | .043 | .048 | .053 | .063 | .076 |

1/ For intermediate thickness, the tolerance of the closer specified gage shall apply. In case of mid-point, the tolerance for lower gage or interpolated value shall apply.

2/ When plates under 60" are rolled double width, the equivalent wider plate tolerance shall apply.

TABLE IV. Permissible variations from flatness.

| Specified Thickness, in. | Variations from a flat surface for specified widths, in. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Over 8 to 36 excl. | 36 to 48 excl. | 48 to 60 excl. | 60 to 72 excl. | 72 to 84 excl. | 84 to 96 excl. | 96 to 108 excl. | 108 to 120 excl. | 120 to 144 incl. |
| Up to 1/4, excl. | 13/16 | 1-1/8 | 1-3/8 | 1-7/8 | 2 | 2-1/4 | 2-3/8 | 2-5/8 | 2-3/4 |
| 1/4 to 3/8, excl. | 3/4 | 15/16 | 1-1/8 | 1-3/8 | 1-3/4 | 1-7/8 | 2 | 2-1/4 | 2-3/8 |
| 3/8 to 1/2, excl. | 3/4 | 7/8 | 15/16 | 15/16 | 1-1/8 | 1-5/16 | 1-1/2 | 1-5/8 | 1-7/8 |
| 1/2 to 3/4, excl. | 5/8 | 3/4 | 13/16 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-5/8 |
| 3/4 to 1, excl. | 5/8 | 3/4 | 7/8 | 7/8 | 15/16 | 1 | 1-1/8 | 1-5/16 | 1-1/2 |
| 1 to 2, incl. | 9/16 | 5/8 | 3/4 | 13/16 | 7/8 | 15/16 | 1 | 1 | 1 |

Note 1 - Flatness tolerances for length - The longer dimension specified in considered the length, and variations from a flat surface along the length should not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. or longer plates.

Note 2 - Flatness toleraces for width - The flatness variations across the width should not exceed the tabular amount for the specified width.

Note 3 - When the longer dimension is under 36 in., the variation should not exceed 3/8 in. When the larger dimension is from 36 to 72 in., incl., the variation should not exceed 75% of the tabular amount for the specified width.





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TABLE V. Waviness tolerances for plates.

| Flatness tolerance from table IV | When number of waves in 12 ft is: 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 3/8 | 3/8 | 5/16 | 3/16 | 3/16 | 1/8 | 1/16 | 1/16 |
| 7/16 | 7/16 | 5/16 | 1/4 | 3/16 | 1/8 | 1/8 | 1/16 |
| 1/2 | 1/2 | 3/8 | 5/16 | 3/16 | 3/16 | 1/8 | 1/16 |
| 9/16 | 9/16 | 7/16 | 5/16 | 1/4 | 3/16 | 1/8 | 1/8 |
| 5/8 | 5/8 | 1/2 | 3/8 | 1/4 | 3/16 | 1/8 | 1/8 |
| 11/16 | 11/16 | 1/2 | 3/8 | 5/16 | 3/16 | 3/16 | 1/8 |
| 3/4 | 3/4 | 9/16 | 7/16 | 5/16 | 1/4 | 3/16 | 1/8 |
| 13/16 | 13/16 | 5/8 | 7/16 | 5/16 | 1/4 | 3/16 | 1/8 |
| 7/8 | 7/8 | 11/16 | 1/2 | 3/8 | 1/4 | 3/16 | 1/8 |
| 15/16 | 15/16 | 11/16 | 1/2 | 3/8 | 5/16 | 1/4 | 3/16 |
| 1 | 1 | 3/4 | 9/16 | 7/16 | 5/16 | 1/4 | 3/16 |
| 1-1/8 | 1-1/8 | 7/8 | 5/8 | 1/2 | 3/8 | 1/4 | 3/16 |
| 1-1/4 | 1-1/4 | 15/16 | 11/16 | 1/2 | 3/8 | 5/16 | 1/4 |
| 1-3/8 | 1-3/8 | 1-1/16 | 3/4 | 9/16 | 7/16 | 5/16 | 1/4 |
| 1-1/2 | 1-1/2 | 1-1/8 | 7/8 | 5/8 | 1/2 | 3/8 | 1/4 |
| 1-5/8 | 1-5/8 | 1-1/4 | 15/16 | 11/16 | 1/2 | 3/8 | 5/16 |
| 1-3/4 | 1-3/4 | 1-5/16 | 1 | 3/4 | 9/16 | 7/16 | 5/16 |
| 1-7/8 | 1-7/8 | 1-7/16 | 1-1/16 | 13/16 | 5/8 | 1/2 | 3/8 |
| 2 | 2 | 1-1/2 | 1-1/8 | 7/8 | 5/8 | 1/2 | 3/8 |
| 2-1/4 | 2-1/4 | 1-11/16 | 1-1/4 | 15/16 | 11/16 | 9/16 | 3/8 |
| 2-3/8 | 2-3/8 | 1-13/16 | 1-5/16 | 1 | 3/4 | 9/16 | 7/16 |
| 2-5/8 | 2-5/8 | 2 | 1-1/2 | 1-1/8 | 13/16 | 5/8 | 7/16 |
| 2-3/4 | 2-3/4 | 2-1/16 | 1-9/16 | 1-1/8 | 7/8 | 5/8 | 1/2 |

NOTES:

NOTE 1 Waviness denotes the deviation of the top or bottom surface from a horizontal line, when the plate is resting on a flat surface, as measured in an increment of less than 12 ft of length. The waviness tolerance is a function of the flatness tolerance as obtained from table IV.

NOTE 2 When the flatness tolerance is 5/8 inch or less for plates 1/2 inch or less in thickness, the waviness tolerance shall not apply.

3.2.8 Identification marking. Identification marking shall be legibly painted and records shall be such as to ensure positive identification of all plates, including test samples and specimens, with the lot and corresponding heat from which they were produced. Marking shall be approximately six inches in from the edge of the plate. The key to identification symbols shall be furnished to the inspector prior to submittal for inspection. First article and acceptance ballistic test plates shall also be marked with the manufacturer's name or trademark, the number of this specification, and the ordered plate thickness in inches. First article plates shall be marked "PRE", acceptance plates "ACC", and retest plates will be marked "R1" and "R2". If a second set of retest plates are submitted they shall be marked "RR1" and "RR2'. The primary plate rolling direction should be identified.

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3.2.9 Workmanship.

3.2.9.1 Surface condition. The top and bottom surface of each plate shall be free from the following surface defects: slivers, laps, checks, seams, blisters, snakes, cold shuts, cracks, burning, mechanical seams, mechanical gouges and laminations (see 6.10). The surface of each plate shall be such that mill scale or oxidation product shall not interfere with determination of acceptablility. Imperfections listed above, which are of such a nature as to affect the fabrication of the materials, are rejectable.

3.2.9.1.1 Depth of imperfections. The depth of rolled-in scale, scale pitting or snakes shall not exceed 0.015 inch and shall not reduce the steel thickness below the allowable minimum. Isolated individual pits over 0.015 inch deep but not over 0.03 inch deep and not within 6 inches of each other and which do not violate the minimum allowable thickness, as specified in the applicable drawings and fabrication documents, are acceptable.

3.2.9.2 Edge preparation. Thermal cutting shall be permitted after final heat treatment provided the procedure, which may include grinding after thermal cutting, is such that no cracks develop on any thermally cut edge whether detected by nondestructive inspection, or as agreed upon in the contract. To reduce the potential for plate cracking, plates shall not be cut by cold shearing after final heat treatment. The heat affected zone of thermally cut plates (up to and including 1/2-inch in thickness) shall not exceed 1.2 times the plates thickness from the cut edge. For plates over 1/2-inch thick, the heat affected zone shall not exceed 5/8-inch from the cut edge. In order to have the heat affected zone exceed these limits approval shall be obtained from the procuring activity.

3.2.9.3 Edge condition. Plate edge on plates delivered after heat treatment shall be free of cracks. The supplier shall practice such necessary process controls to prevent this condition.

3.2.9.4 Edge quality. For all plates the steel supplier shall institute such necessary controls such that any cut parts shall comply with the requirements of 3.2.9.4.1, whether detected by magnetic particle inspection, or liquid penetrant inspection.

3.2.9.4.1 Acceptance criteria.

3.2.9.4.1.1 Single linear indications. In any four inches of length a single linear indication shall not exceed twice the plate thickness.

3.2.9.4.1.2 Multiple linear indications. Multiple linear indications shall not exceed 1-1/2 times the plate thickness if two or more lie in the same plane. The total length of indications in one plane, in any four inch length, shall not exceed twice the plate thickness. No more than ten indications, whether in one plane or multiple planes, are permitted in any four inch length.

3.2.9.4.1.3 Cracks. All cracks are rejectable.

3.2.9.4.1.4 Removal of large indications. Large indications shall be removed by the manufacturer or processor by grinding, provided the resulting cavity does not exceed 1/4 inch.

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## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor is responsible for the performace of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the contractor may use his own or any other facility suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specifications where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification.

4.2.1 Classification of inspection. The inspection requirements specified herein are classified as follows:

1. First article inspection (see 4.2.1.1).
2. Quality conformance inspection (see 4.2.1.2).

4.2.1.1 First article inspection. When required (see 6.2), the first article samples submitted in accordance with 3.1, shall be examined for all the provisions of this specification applicable to end item examination.

4.2.1.1.1 First article tests. First article tests shall consist of all the tests specified in 4.6 (see 6.2.2).

4.2.1.1.2 First article ballistic test. Unless otherwise specified (see 3.1, 6.2 and 6.4), the first article ballistic test shall not be required provided (a) the manufacturer, within 37 months, has produced acceptable plates within the same nominal thickness ranges of table VI and (b) his production conditions are the same as for previously accepted plates. A supplier who has previously met the first article requirements will furnish the procuring activity with the pertinent data relative to compliance with first article test.

4.2.1.2 Quality conformance (acceptance) inspection. The acceptance examination under 4.5 and the tests under 4.6 shall serve as a basis for the acceptance of individual production lots.

4.3 Lot. A lot shall consist of all production and ballistic test plates of the same melt of steel, of the same thickness, having the same treatment, and heat-treated with the same thermal cycle in the same production furnace(s) in the same facility. When specified (see 4.3.1 and 6.2), production and

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ballistic test plates may be allowed to be heat-treated separately. The test plate shall be heat-treated in a production furnace.

4.3.1 Separately heat treated ballistic test plate. When a ballistic test plate is allowed to be heat-treated separately from the production plates it represents, the production plates shall remain in the non-heat treated condition (as rolled condition only) until the results are received from the testing activity showing that the ballistic test plate has passed (see 6.15). Note: If the ballistic test plate is separately heat-treated it will be so stated in the data to be supplied in accordance with MIL-STD-367.

4.4 Sampling.

4.4.1 For first article.

4.4.1.1 Chemical analysis samples. One sample for chemical analysis shall be taken from each plate submitted.

4.4.1.2 Impact samples. At least two impact test specimens shall be taken from each test plate submitted for ballistic testing.

4.4.1.3 Ballistic samples. Two ballistic test plates of the same ordered thickness for each nominal thickness range shown in table VI below shall be submitted for ballistic testing and shall represent any other thickness in the range. One sample shall be taken from the first plate heat treated and one from the last plate heat treated in the initial lot produced. When only one plate is heat treated, a sample shall be taken from each end of the plate. The ballistic test plates shall be 12 inches by 36 inches.

TABLE VI. Thickness ranges and corresponding test projectiles for first article testing (a).

| Nominal thickness range (inches) | Obliquity (degrees) | Test Projectile |
|---|---|---|
| 0.125 to 0.300 incl. | 30 | Cal .30 AP, M2 |
| 0.301 to 0.590 incl. | 30 | Cal .50 AP, M2 |
| 0.591 to 0.765 incl. | 30 | 14.5 mm API, B32 |
| 0.766 to 1.065 incl. | 30 | 14.5 mm API, BS41 |
| 1.066 to 2.000 incl. | 0 | 20 mm API-T, M602 |

(a) Minimum required ballistic limits are tabulated in tables VII through X of the Appendix. The plates are tested at $30^0$ obliquity.

4.4.1.4 Bend test samples. Unless otherwise specified (see 6.2), two samples shall be taken from each submitted test plate and shall be tested in accordance with 4.6.4 and shall meet the requirements of 3.2.5.

4.4.2 Sampling for quality conformance inspection.

4.4.2.1 For chemical analysis. At least one sample for chemical analysis shall be taken from each heat in accordance with the applicable method specified in ASTM A751 (see 6.5).

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4.4.2.2 For hardness tests. The Brinell hardness of each plate, as heat-treated, shall be measured in two places, one at each end of a diagonal on one surface of the plate.

4.4.2.3 For Charpy V-notch impact tests. A sample shall be taken from a plate representing each lot for Charpy V-notch impact tests. The sample shall be the same thickness as the plate it represents and large enough to obtain at least four specimens from the sample in accordance with 4.6.3.

4.4.2.4 For ballistic acceptance testing. One plate, of each thickness to be supplied on the contract, shall be randomly taken from each lot for ballistic testing. In the event that two ordered thicknesses that are 0.010 inches or less apart, are to be made from the same lot, then only one of the ordered thicknesses need be submitted for acceptance testing. The other ordered thickness, however, shall be included on the applicable reporting form in accordance with MIL-STD-367, with the words indicating that it is represented by the sample to be tested. However, if the two ordered thicknesses are such that each thickness requires testing with a different type projectile as shown in table VI, then each of the ordered thicknesses shall be ballistically tested. Unless otherwise specified, the plates shall be 12 inches by 36 inches. Test projectiles will be as specified in table VI.

4.4.2.5 Bend test samples. Unless otherwise specified (see 6.2), two samples shall be randomly taken from each lot for these tests representing the entire lot of material; however, when an entire heat represents only one lot the samples shall be taken from the first and last usable portion of the heat. Testing shall be conducted in accordance with 4.6.4 and shall meet the requirements of 3.2.5.

4.4.2.6 Thermally cut plates. For plates thermally cut after heat treatment, one sample plate per thickness shall be sampled and tested for hardness at two (2) locations perpendicular to the cut edge in accordance with 3.2.9.2. Plates not meeting the minimum requirement of 3.2.4.1 shall be rejected. In addition, the edges of the plates shall be examined nondestructively for cracks after cutting.

4.4.2.7 Ultrasonic inspection. All plates 1/2-inch and greater in thickness shall be inspected ultrasonically for soundness in accordance with 4.6.6.

4.5 Examination.

4.5.1 Visual. All steel plate shall be subject to visual inspection for compliance with the requirements for identification marking (see 3.2.8) and for workmanship (see 3.2.9).

4.5.2 Dimensional. All steel plate shall be subject to inspection for compliance with dimensional and tolerance requirements (see 3.2.7).

4.5.3 Preparation for shipment. Examination shall be made to determine compliance with the requirements for preparation for shipment (see section 5).

4.6. Tests.

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4.6.1 Chemical analysis. Chemical analysis shall be conducted in accordance with the applicable method specified in ASTM A751 (see 6.5). The analysis shall comply with the declared composition established in accordance with the requirements of table I (see 3.2.1).

4.6.2 Hardness tests. Brinell hardness tests (HB) shall be conducted in accordance with ASTM E10, using a 10mm carbide ball and a 3000 kilogram load. Surface scale and decarburization shall be removed from the areas where the tests are to be made. However, no more that 0.060" shall be removed from the test area. Hardness tests may be made on the surfaces of pieces cut from the plate after heat treatment.

4.6.2.1 Rockwell hardness tests. For plates less than 3/16 inch in thickness, Rockwell - C hardness tests (HRC) shall be substituted for HB tests. Tests shall be conducted in accordance with ASTM E18 and the readings shall be converted to HB.

4.6.3 Charpy V-notch impact tests. At least four Charpy V-notch impact test specimens shall be taken from the sample and shall be prepared and tested in accordance with ASTM E23. Charpy V-notch impact test specimens shall be taken in both the TL orientation and in the LT orientation from locations midway between the top and bottom surfaces of the plate and at least 4 inches or 2T, whichever is less, from any quenched edge as well as outside the heat affected zone of any oxygen-cut edge. The largest attainable subsize Charpy V-notch impact specimens shown in figure 7 of ASTM E23 shall be used.

4.6.4 Bend test: The bend test shall be conducted in accordance with ASTM E290 using method Arrangement C.

4.6.5 Ballistic tests. Ballistic testing of armor plate shall be conducted at a Government test facility specified in the contract or order (see 6.2). Testing shall be conducted in accordance with the requirements of the appendix of this specification.

4.6.6 Ultrasonic examination.

4.6.6.1 Inspection equipment. The ultrasonic soundness inspection equipment shall conform to ASTM A578.

4.6.6.2 Procedure. Unless otherwise specified (see 6.2) the ultrasonic examination shall be carried out in accordance with ASTM A578 with the following exceptions.

(a) Scanning shall be continuous over 100% of the plate surface.

(b) Scanning rate shall be at a speed where recordable discontinuities can be detected.

(c) The testing frequency shall be a minimum of 2-1/4 megahertz (MHz).

(d) Any area within a plate where a discontinuity produces a continuous total loss of back reflection accompanied by continuous indications on the same plane that cannot be encompassed within a circle whose diameter is 1-in. shall be cause for rejection of that plate. All discontinuities will be evaluated using a frequency of 2-1/4 megahertz (MHz).

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4.6.6.3 Certification of inspection personnel. Unless otherwise specified (see 6.2), personnel performing ultrasonic inspection shall comply with the qualification requirements of MIL-STD-410, level II, or equivalent, as determined by QSTAG 335 (see 6.11).

4.7 Reduced testing. At the discretion of the procuring activity, the amount of testing may be reduced provided the results on consecutive lots indicate that a satisfactory uniform product meeting the testing requirements is being produced (see 6.2). Reduced testing shall be in accordance with a system previously approved or established by the procuring activity involved.

4.8 Rejection and retest.

4.8.1 Rejection. Unless otherwise specified in the contract or order (see 6.2), failure of the first article samples to meet the requirements of this specification shall be cause for rejection of the process, failure of the acceptance samples to meet the requirements of this specification shall be cause for rejection of the lot (see 4.8.2).

4.8.2 Retest. Unless specific retest procedure is specified in the contract or order (see 6.2), two retest samples shall be submitted for each failed sample. Failure of either of the retest samples (plates) shall be cause for rejection of the material. First article retests shall not be permitted until the supplier has made the necessary corrections in the processing of the material to the satisfaction of the procuring activity.

5. PACKAGING

5.1 Preservation and packaging. Preservation and packaging shall be level A or C as specified (see 6.2).

5.1.1 Level A. Cleaning, drying, preservation, and packaging shall be in accordance with MIL-STD-163.

5.1.2 Level C. Cleaning, drying, preservation, and packaging shall be in accordance with manufacturer's commercial practice.

5.2 Packing. Packing shall be level A or level C as specified (see 6.2).

5.2.1 Level A. Packing shall be in accordance with MIL-STD-163.

5.2.2 Level C. Packing shall be in accordance with commercial practice adequate to ensure acceptance and safe delivery by the carrier for the mode of transportation employed.

5.3 Marking. In addition to any special marking specified in the contract or order, shipments shall be marked in accordance with the requirements of MIL-STD-129.

6. NOTES

6.1 Intended use. The steel armor covered by this specification is intended for lightweight applications where resistance to ball and armor piercing types of ammunition and multiple hit capability are required.

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6.2 Ordering data.

6.2.1 Procurement requirements. Procurement documents should specify the following:

a. Title, number and date of this specification
b. If first article samples are to be made available (see 3.1).
c. If additional heat treatment may be performed (see 3.2).
d. If plates may be furnished in a condition other than in 3.2.2.
e. Dimensions (see 3.2.7).
f. Name of inspection agency when inspection shall be performed by other than the contractor (see 4.1).
g. If first article testing is required (see 4.2.1.1).
h. When a special first article ballistic tested is required (see 3.1, 4.2.1.1.2 and 6.9).
i. If lot is different than 4.3.
j. Production sampling if other than in 4.4.2.5.
k. If different certification of inspection personnel is required (see 4.6.6.3).
l. Where ballistic testing is to be conducted (see 4.6.5).
m. The reduced testing plan when applicable (see 4.7).
n. If rejection and retest differ from 4.8.
o. Preparation for delivery requirements (see section 5).
p. If different ultrasonic test procedures are required (see 4.6.6.2).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DOD FAR supplement, Part 27, Sub-Part 27.475-1 (DDForm 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

| Paragraph No. | Data Requirement Title | Applicable DID No. | Option |
|---|---|---|---|
| 3.1, 4.2.1.1.1 | Report, First Article Test | UDI-T-23790 | |
| 3.2.1 | Armor Material Test Reports | DI-MISC-80073 | Format I |

(Copies of DID's required by contractors in connection with specific acquisition functions should be obtained from the Naval Publication and Forms Center or as directed by the contracting officer.)

6.3 Fabrication. The armor plate covered by this specification is subject to fabrication involving cutting, drilling, forming, and welding. It is intended that selection and control of chemical composition, cleanliness, and plate processing will be such that the armor will be suitable for fabrication under procedures and controls such as specified in MIL-STD-1185, Welding High Hardness Armor.

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6.3.1 Plate Cutting. To reduce the potential for plate cracking, it is important that plates should not be cut by cold shearing after final heat treatment.

6.4 Special First Article ballistic test. Special first article ballistic tests are required when the manufacturer changes either the heat treatment or the declared chemistry of the armor.

6.5 Chemical analysis. Suggested ASTM instrumental methods that can be used for chemical analysis are E415, E282, E484 and E322. ASTM A751 should be consulted for a complete list of methods.

6.6 MIL-STD-367. MIL-STD-367 replaces Form MIL 46100 and TAC Form 3983.

6.7 Potential suppliers. Potential suppliers who have not previously supplied armor plate to MIL-A-46100 and wish to have their material ballistically tested, may do so at their own expense. It is recommended that inquiries for such testing be directed to Commander, US Army CSTA, ATTN: AMSTE-TO-O, Aberdeen Proving Ground, MD 21005.

6.8 Metric units. When metric dimensions are required, units for inch, foot, foot-pounds and feet per second may be coverted to the metric equivalent by multiplying them by the following conversion factors:

| English | Multiply by | Equals | Metric SI unit |
|---|---|---|---|
| inch | 0.0254 | = | meter (m) |
| foot | 0.3048 | = | meter (m) |
| foot-lb | 1.3558 | = | joule (J) |
| feet/sec | 0.3048 | = | meter per second (m/s) |

Note: Conversion factors can be associated with ASTM E380 entitled "Metric Practice Guide."

6.9 New contracts sponsored by government agencies. At the time that a new contract is initiated for the production of combat vehicles, the contractor's supplier is to estimate the number, size and delivery schedule of the ballistic test plates which are to be submitted for first article or acceptance testing (see 6.2). A lead time of 60 days after the contract has been signed is to be allowed prior to shipment of the first ballistic test(s) to APG to insure that all administrative functions for the establishment of a new CSTA project have been completed in preparation for the test. The contracting government activity is to initiate the new project through a letter to Commander, US Army CSTA, ATTN: AMSTE-TO-O, Aberdeen Proving Ground, MD 21005-5059 requesting a cost estimate for the ballistic testing of the applicable number and sizes of plates. In the case of increases in scope of existing projects, similar correspondence is needed.

6.10 Definitions.

6.10.1 Slivers. An imperfection consisting of a very thin elongated piece of metal attached by only one end to the parent metal into whose surface it has been worked.

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6.10.2 Laps. A surface imperfection with the appearance of a seam, caused by hot metal, fins or sharp corners being folded over and thus being forged or rolled into the surface but without being welded.

6.10.3 Checks. Numerous very fine cracks at the surface of a metal part. Checks may appear during processing or during service and are most often associated with thermal cycling or thermal treatment. Also called check marks, checking, heat checks.

6.10.4 Seams. An unwelded fold or lap that appears as a crack, usually resulting from a discontinuity on a metal surface.

6.10.5 Blisters. A raised area, often dome shaped, resulting from delamination under pressure of expanding gas trapped in metal in a near sub-surface zone. Very small blisters may be called pinhead blisters or pepper blisters.

6.10.6 Snakes. Any crooked surface imperfection in a metal plate, resembling a snake.

6.10.7 Cold shuts. A lap on the surface of a forging or billet that was closed without fusion during deformation.

6.10.8 Burning. Permanently damaged metal due to overheating enough to cause incipient melting or intergranular oxidations. Note: This condition is usually obscured by normal cleaning methods and would require deep pickling and/or metallography to note the continuous oxidation (chicken wire effect) of the enlarged grain boundaries. This defect is usually not limited to the surface and may be sub-surface or at interior locations when associated with heavy mechanical working. Metal with these conditions shall be scrapped.

6.10.9 Laminations. A type of discontinuity with separation or weakness generally aligned parallel to direction of the worked surface of the metal and may be the result of pipe blisters, seams, inclusions, or segregation elongated and made directional by working.

6.10.10 Linear indication. For nondestructive examination purposes, a linear indication is evidence of a discontinuity that requires interpretation to determine its significance.

6.11 Quadripartite standardization agreement (QSTAG). QSTAG 335, pertaining to the certification of personnel for ultrasonic inspection, states that level I of Canadian Government specification Board Standard 48-GP-7M is equivalent to MIL-STD-410, level II.

6.12 Certain provisions of this specification (see 6.11) are the subject of international standardization agreement (QSTAG 335). When amendment, revision, or cancellation of this specification is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardizational offices to change the agreement or make other appropriate accommodations.

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6.13 Plates in the as-rolled condition. When the fabricator performs the final quench and temper of plates, it shall be his responsibility that the mechanical and ballistic requirements of the plates, meet this specification.

6.14 Subject term (key word) listing.

| | |
|---|---|
| Armor - lightweight | Heat-treated armor plates |
| Ballistic testing | Wrought steel, high-hardness |

6.15 Caution for production plates. Material made to this specification has a tendency to develop stress cracks if not tempered as soon as possible after austenizing. To avoid this situation where plates may be left in the austenized condition and in the untempered state while waiting to receive the results of the ballistic test plate representing the lot, all the plates in the lot shall be left in the as-rolled (unheat-treated) condition.

Custodian:
Army - MR

Preparing activity:
Army - MR

Review activities:
Army - AT, EA, AR, TE
DLA - IS

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# APPENDIX

## BALLISTIC TESTING OF ARMOR PLATE, STEEL, WROUGHT HIGH HARDNESS

10. SCOPE

10.1 This appendix covers the requirements for ballistic testing of high hardness steel armor plate.

20. DEFINITIONS

20.1 Fair impact. A fair impact is an impact resulting from the striking of the test plate by a projectile in normal flight (no yawing or tumbling) and separated from another impact or the edge of the plate, hole, crack, or spalled area by an undisturbed area of at least two test projectile diameters.

20.2 Witness sheet. A witness sheet is normally a 0.014 inch thick sheet of 5052 H36 aluminum alloy (or a 0.020 inch thick sheet of 2024-T3 aluminum alloy) placed 6 inches (+1/2 inch) behind and parallel to the test plate or other ballistic sample.

20.3 Complete penetration, protection, CP(P). A protection complete penetration is a penetration in which the projectile or one or more fragments of the projectile or plate pass beyond the back of the test plate and perforates the witness plate.

20.4 Partial penetration, protection, PP(P). A partial penetration is any impact that is not a complete pentration.

20.5 Gap. The difference in velocity between the high partial penetration velocity and the low complete penetration velocity used in computing the ballistic limit where the high partial penetration velocity is lower than the low complete penetration velocity.

20.6 $V_{50}$ protection ballistic limit, BL(P). The protection $V_{50}$ ballistic limit is defined as the average of 6 fair impact velocities comprising the three lowest velocities resulting in complete penetration and the three highest velocities resulting in partial penetration. A maximum spread of 150 feet per second shall be permitted between the lowest and highest velocities employed in determination of ballistic limits. In only those cases where the lowest complete penetration velocity is lower than the highest parital penetration velocity by more than 150 fps will the ballistic limit be based on 10 velocities (the 5 lowest velocities that resulted in complete penetration and the 5 highest velocities that resulted in partial penetrations). When the 10-round excessive spread, ballistic limit is used, the velocity spread will be reduced to the lowest partical level (as close to 150 fps as possible). When a 10-round ballistic limit is used, this will be noted in all reports. The normal up-and-down firing method will be used in the determination of all BL(P)'s, all velocities being corrected to striking velocity. In the event that the ballistic limit computed is less than 30 fps above the minimum required and if a gap (high partial penetration velocity below the low complete penetration velocity) of 30 fps or more exists, firing will continue as needed to reduce this gap to 25 fps or less. (This procedure will insure better evaluation of the steel when the ballistic limit is near the minimum required.)

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20.7 Thickness, impact area. The thickness of ballistic test plates used for determining ballistic limits shall be that of the area subjected to the ballistic testing.

30. REQUIREMENTS

30.1 Resistance to penetration. The minimum ballistic limits shall be in accordance with the values shown in tables VII, VIII, IX, X or XI as applicable.

30.2 Resistance to cracking. Ballistic test plates when visually examined after testing shall not develop any through-crack greater in length than five calibers of the projectile.

40. TESTS

40.1 Ballistic tests. $V_{50}$ ballistic tests shall be performed in accordance with USATECOM TOP 2-2-170, Ballistic Tests of Armor Materials to determine compliance with the requirements of tables VII through XI.

40.1.1 Plate thickness as measured by the ballistic test agency shall be used to determine the required ballistic limit for the plate. Individual thickness measurements are to be read from a micrometer to the nearest 0.001 inch and the average of these readings reported to the nearest 0.001 inch. At least one measurement shall be taken along each edge of the plate at a distance of at least one inch from the edge, but preferably in the area which will be impacted. The average of the measurements to the nearest 0.001 inch will be used to determine the minimum ballistic limit requirements in the appropriate tables (tables VII through XI). The required ballistic limit will be determined by interpolation, if necessary, in the tables in the appendix.

40.1.2 Rejection and retest of ballistic plates.

40.1.2.1 First article tests (rejection). Unless noted otherwise in the contract or order, failure of either of the first article test plates to meet the minimum ballistic requirements as specified in the appendix to this specification indicates failure of the product and process.

40.1.2.2 First article (retests). Resubmission of ballistic retest plates shall not be made until the manufacturer has made the necessary corrections in the processing of the material to the satisfaction of the procuring activity. Two retest plates must be submitted for first article testing and both must pass.

40.1.2.3 Acceptance tests (rejection). Unless otherwise noted in the contract or order, failure of a test plate to meet the ballistic requirements indicates failure of the lot, however, the final decision will depend on the outcome of retests, if submitted.

40.1.2.4 Acceptance tests (retests). If a test plate representing a lot fails to meet the ballistic requirements, the manufacturer has the following options: Immediately upon notification of the failure, he may:

(1) At his own expense submit two additional test plates from the same lot for ballistic retest, or

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(2) He may first re-heat-treat (quenching and tempering) the lot and then submit a test plate from the re-treated lot, or

(3) He may scrap the lot and submit a plate representing a new lot for acceptance.

If he chooses any one of these options and the ballistic retest plate (or plates) meet the requirements, then the lot represented is acceptable. If he chooses option (1) and one or both of the retest plates fail, the manufacturer may re-heat-treat the lot and submit a test plate from the retreated lot. If this plate fails, the lot is rejected. If he chooses option (3) and the test plate fails, he may again resort to any one of the three options. The manufacturer shall report the processing used on the failed plates.

40.1.3 Dispostion of ballistic test plates.

40.1.3.1 First article test plates. Upon request of the applicant within 15 days after ballistic testing, first article plates will be returned "as is" to the applicant, at his expense, unless the plates were destroyed in testing.

40.1.3.2 Acceptance test plates. Acceptance test plates that comply with the requirements of this specification are considered as part of the lot of steel they represent and ownership of them passes to the Government with the acceptance of that lot. Acceptance test plates that fail to comply with the requirements of this specification are considered as part of the lot they represent and remain the property of the producer just as the rejectable lot does. The failed plates will be returned, upon request, as in 40.1.3.1.

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TABLE VII. Minimum required ballistic limits - Caliber .30 AP M2 Projectile at 30 degrees Obliquity.

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 0.100 | 994 | 0.185 | 1799 | 0.265 | 2328 |
| 0.105 | 1057 | 0.190 | 1836 | 0.270 | 2357 |
| 0.110 | 1116 | 0.195 | 1872 | 0.275 | 2386 |
| 0.115 | 1172 | 0.200 | 1908 | 0.280 | 2415 |
| 0.120 | 1226 | 0.205 | 1943 | 0.285 | 2443 |
| 1/ 0.125 | 1279 | 0.210 | 1978 | 0.290 | 2471 |
| 0.130 | 1329 | 0.215 | 2012 | 0.295 | 2499 |
| 0.135 | 1378 | 0.220 | 2046 | 0.300 | 2526 |
| 0.140 | 1425 | 0.225 | 2079 | 0.305 | 2554 |
| 0.145 | 1471 | 0.230 | 2111 | 0.310 | 2581 |
| 0.150 | 1515 | 0.235 | 2144 | 2/ 0.315 | 2607 |
| 0.155 | 1558 | 0.240 | 2175 | 0.320 | 2634 |
| 0.160 | 1601 | 0.245 | 2207 | 0.325 | 2660 |
| 0.165 | 1642 | 0.250 | 2237 | 0.330 | 2686 |
| 0.170 | 1682 | 0.255 | 2268 | 0.335 | 2711 |
| 0.175 | 1722 | 0.260 | 2298 | 0.340 | 2737 |
| 0.180 | 1761 | | | | |

1/ Specification requirements begin for this ordered thickness.
2/ Specification requirements end for this ordered thickness.

Note: Numbers above and below upper and lower limits are requirements for within the tolerance limits.

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TABLE VIII. Minimum required ballistic limits - Caliber .50 AP M2 Projectile at 30 degrees Obliquity.

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 0.290 | 1783 | 0.400 | 2151 | 0.515 | 2481 |
| 0.295 | 1801 | 0.405 | 2166 | 0.520 | 2494 |
| 0.300 | 1820 | 0.410 | 2182 | 0.525 | 2508 |
| 0.305 | 1837 | 0.415 | 2197 | 0.530 | 2521 |
| 0.310 | 1855 | 0.420 | 2212 | 0.535 | 2534 |
| 0.315 | 1873 | 0.425 | 2227 | 0.540 | 2547 |
| 1/ 0.316 | 1876 | 0.430 | 2242 | 0.545 | 2560 |
| 0.320 | 1890 | 0.435 | 2256 | 0.550 | 2573 |
| 0.325 | 1907 | 0.440 | 2271 | 0.555 | 2586 |
| 0.330 | 1925 | 0.445 | 2286 | 0.560 | 2599 |
| 0.335 | 1942 | 0.450 | 2300 | 0.565 | 2612 |
| 0.340 | 1958 | 0.455 | 2314 | 0.570 | 2625 |
| 0.345 | 1975 | 0.460 | 2329 | 0.575 | 2638 |
| 0.350 | 1992 | 0.465 | 2343 | 0.580 | 2650 |
| 0.355 | 2008 | 0.470 | 2357 | 0.585 | 2663 |
| 0.360 | 2025 | 0.475 | 2371 | 2/ 0.590 | 2675 |
| 0.365 | 2041 | 0.480 | 2385 | 0.595 | 2688 |
| 0.370 | 2057 | 0.485 | 2399 | 0.600 | 2700 |
| 0.375 | 2073 | 0.490 | 2413 | 0.605 | 2713 |
| 0.380 | 2089 | 0.495 | 2427 | 0.610 | 2725 |
| 0.385 | 2104 | 0.500 | 2440 | 0.615 | 2737 |
| 0.390 | 2120 | 0.505 | 2454 | 0.620 | 2750 |
| 0.395 | 2136 | 0.510 | 2468 | 0.625 | 2762 |

1/ Specification requirements begin for this ordered thickness.
2/ Specification requirements end for this ordered thickness.

Note: Numbers above and below upper and lower limits are requirements for within the tolerance limits.

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TABLE IX. Minimum required ballistic limits - 14.5 mm API B 32 Projectile at 30 degrees Obliquity.

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 0.575 | 2320 | 0.645 | 2469 | 0.720 | 2621 |
| 0.580 | 2331 | 0.650 | 2480 | 0.725 | 2630 |
| 0.585 | 2342 | 0.655 | 2490 | 0.730 | 2640 |
| 0.590 | 2353 | 0.660 | 2500 | 0.735 | 2650 |
| 1/ 0.591 | 2355 | 0.665 | 2511 | 0.740 | 2659 |
| 0.595 | 2364 | 0.670 | 2521 | 0.745 | 2669 |
| 0.600 | 2374 | 0.675 | 2531 | 0.750 | 2679 |
| 0.605 | 2385 | 0.680 | 2541 | 0.755 | 2688 |
| 0.610 | 2396 | 0.685 | 2551 | 0.760 | 2698 |
| 0.615 | 2407 | 0.690 | 2561 | 2/ 0.765 | 2707 |
| 0.620 | 2417 | 0.695 | 2571 | 0.770 | 2717 |
| 0.625 | 2428 | 0.700 | 2581 | 0.775 | 2726 |
| 0.630 | 2438 | 0.705 | 2591 | 0.780 | 2736 |
| 0.635 | 2449 | 0.710 | 2601 | 0.785 | 2745 |
| 0.640 | 2459 | 0.715 | 2611 | 0.790 | 2754 |

1/ Specification requirements begin for this ordered thickness.
2/ Specification requirements end for this ordered thickness.

Note: Numbers above and below upper and lower limits are requirements for within the tolerance limits.

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TABLE X. Minimum required ballistic limits - 14.5 mm API BS41 Projectile at 30 degrees Obliquity.

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 0.740 | 2212 | 0.855 | 2505 | 0.975 | 2779 |
| 0.745 | 2225 | 0.860 | 2517 | 0.980 | 2790 |
| 0.750 | 2239 | 0.865 | 2529 | 0.985 | 2800 |
| 0.755 | 2252 | 0.870 | 2540 | 0.990 | 2811 |
| 0.760 | 2265 | 0.875 | 2552 | 0.995 | 2822 |
| 0.765 | 2278 | 0.880 | 2564 | 1.000 | 2822 |
| 1/ 0.766 | 2281 | 0.885 | 2576 | 1.005 | 2843 |
| 0.770 | 2292 | 0.890 | 2588 | 1.010 | 2854 |
| 0.775 | 2305 | 0.895 | 2599 | 1.015 | 2865 |
| 0.780 | 2318 | 0.900 | 2611 | 1.020 | 2875 |
| 0.785 | 2331 | 0.905 | 2622 | 1.025 | 2886 |
| 0.790 | 2343 | 0.910 | 2634 | 1.030 | 2896 |
| 0.795 | 2356 | 0.915 | 2645 | 1.035 | 2907 |
| 0.800 | 2369 | 0.920 | 2657 | 1.040 | 2917 |
| 0.805 | 2382 | 0.925 | 2668 | 1.045 | 2927 |
| 0.810 | 2394 | 0.930 | 2679 | 1.050 | 2938 |
| 0.815 | 2407 | 0.935 | 2690 | 1.055 | 2948 |
| 0.820 | 2419 | 0.940 | 2702 | 1.060 | 2958 |
| 0.825 | 2431 | 0.945 | 2713 | 2/ 1.065 | 2968 |
| 0.830 | 2444 | 0.950 | 2724 | 1.070 | 2979 |
| 0.835 | 2456 | 0.955 | 2735 | 1.075 | 2989 |
| 0.840 | 2468 | 0.960 | 2746 | 1.080 | 2999 |
| 0.845 | 2481 | 0.965 | 2757 | 1.085 | 3009 |
| 0.850 | 2493 | 0.970 | 2768 | 1.090 | 3019 |

1/ Specification requirements begin for this ordered thickness.
2/ Specification requirements end for this ordered thickness.

Note: Numbers above and below upper and lower limits are requirements for within the tolerance limits.

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TABLE XI. Minimum required ballistic limits - 20 mm API-T, M602 Projectile at 0 degrees Obliquity.

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 1.020 | 1758 | 1.215 | 2088 | 1.415 | 2382 |
| 1.025 | 1767 | 1.220 | 2096 | 1.420 | 2389 |
| 1.030 | 1776 | 1.225 | 2104 | 1.425 | 2396 |
| 1.035 | 1785 | 1.230 | 2112 | 1.430 | 2402 |
| 1.040 | 1794 | 1.235 | 2120 | 1.435 | 2409 |
| 1.045 | 1804 | 1.240 | 2127 | 1.440 | 2416 |
| 1.050 | 1813 | 1.245 | 2135 | 1.445 | 2423 |
| 1.055 | 1821 | 1.250 | 2143 | 1.450 | 2430 |
| 1.060 | 1830 | 1.255 | 2150 | 1.455 | 2436 |
| 1.065 | 1839 | 1.260 | 2158 | 1.460 | 2443 |
| 1/ 1.066 | 1841 | 1.265 | 2165 | 1.465 | 2450 |
| 1.070 | 1848 | 1.270 | 2173 | 1.470 | 2457 |
| 1.075 | 1857 | 1.275 | 2180 | 1.475 | 2463 |
| 1.080 | 1866 | 1.280 | 2188 | 1.480 | 2470 |
| 1.085 | 1874 | 1.285 | 2195 | 1.485 | 2477 |
| 1.090 | 1883 | 1.290 | 2203 | 1.490 | 2483 |
| 1.095 | 1892 | 1.295 | 2210 | 1.495 | 2490 |
| 1.100 | 1900 | 1.300 | 2218 | 1.500 | 2496 |
| 1.105 | 1909 | 1.305 | 2225 | 1.505 | 2503 |
| 1.110 | 1917 | 1.310 | 2232 | 1.510 | 2510 |
| 1.115 | 1926 | 1.315 | 2240 | 1.515 | 2516 |
| 1.120 | 1934 | 1.320 | 2247 | 1.520 | 2523 |
| 1.125 | 1943 | 1.325 | 2254 | 1.525 | 2529 |
| 1.130 | 1951 | 1.330 | 2262 | 1.530 | 2536 |
| 1.135 | 1959 | 1.335 | 2269 | 1.535 | 2542 |
| 1.140 | 1968 | 1.340 | 2276 | 1.540 | 2549 |
| 1.145 | 1976 | 1.345 | 2283 | 1.545 | 2555 |
| 1.150 | 1984 | 1.350 | 2290 | 1.550 | 2561 |
| 1.155 | 1992 | 1.355 | 2298 | 1.555 | 2568 |
| 1.160 | 2001 | 1.360 | 2305 | 1.560 | 2574 |
| 1.165 | 2009 | 1.365 | 2312 | 1.565 | 2581 |
| 1.170 | 2017 | 1.370 | 2319 | 1.570 | 2587 |
| 1.175 | 2025 | 1.375 | 2326 | 1.575 | 2593 |
| 1.180 | 2033 | 1.380 | 2333 | 1.580 | 2600 |
| 1.185 | 2041 | 1.385 | 2340 | 1.585 | 2606 |
| 1.190 | 2049 | 1.390 | 2347 | 1.590 | 2612 |
| 1.195 | 2057 | 1.395 | 2354 | 1.595 | 2619 |
| 1.200 | 2065 | 1.400 | 2361 | 1.600 | 2625 |
| 1.205 | 2073 | 1.405 | 2368 | 1.605 | 2631 |
| 1.210 | 2081 | 1.410 | 2375 | 1.610 | 2637 |

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TABLE XI. Minimum required ballistic limits - 20 mm API-T, M602 Projectile at 0 degrees Obliquity. (Continued)

| Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS | Thickness inches | Required BL(P) FPS |
|---|---|---|---|---|---|
| 1.615 | 2644 | 1.805 | 2871 | 1.995 | 3082 |
| 1.620 | 2650 | 1.810 | 2877 | 2.000 | 3088 |
| 1.625 | 2656 | 1.815 | 2883 | 2.005 | 3093 |
| 1.630 | 2662 | 1.820 | 2888 | 2.010 | 3098 |
| 1.635 | 2669 | 1.825 | 2894 | 2.015 | 3104 |
| 1.640 | 2675 | 1.830 | 2900 | 2.020 | 3109 |
| 1.645 | 2681 | 1.835 | 2905 | 2.025 | 3114 |
| 1.650 | 2687 | 1.840 | 2911 | 2.030 | 3120 |
| 1.655 | 2693 | 1.845 | 2917 | 2.035 | 3125 |
| 1.660 | 2699 | 1.850 | 2922 | 2.040 | 3130 |
| 1.665 | 2705 | 1.855 | 2928 | 2.045 | 3135 |
| 1.670 | 2711 | 1.860 | 2934 | 2.050 | 3141 |
| 1.675 | 2718 | 1.865 | 2939 | 2.055 | 3146 |
| 1.680 | 2724 | 1.870 | 2945 | 2.060 | 3151 |
| 1.685 | 2730 | 1.875 | 2951 | 2.065 | 3156 |
| 1.690 | 2736 | 1.880 | 2956 | 2.070 | 3162 |
| 1.695 | 2742 | 1.885 | 2962 | 2.075 | 3167 |
| 1.700 | 2748 | 1.890 | 2967 | 2.080 | 3172 |
| 1.705 | 2754 | 1.895 | 2973 | 2.085 | 3177 |
| 1.710 | 2760 | 1.900 | 2978 | 2.090 | 3183 |
| 1.715 | 2766 | 1.905 | 2984 | 2.095 | 3188 |
| 1.720 | 2772 | 1.910 | 2990 | 2/ 2.100 | 3193 |
| 1.725 | 2778 | 1.915 | 2995 | 2.105 | 3198 |
| 1.730 | 2784 | 1.920 | 3001 | 2.110 | 3203 |
| 1.735 | 2789 | 1.925 | 3006 | 2.115 | 3208 |
| 1.740 | 2795 | 1.930 | 3012 | 2.120 | 3214 |
| 1.745 | 2801 | 1.935 | 3017 | 2.125 | 3219 |
| 1.750 | 2807 | 1.940 | 3023 | 2.130 | 3224 |
| 1.755 | 2813 | 1.945 | 3028 | 2.135 | 3229 |
| 1.760 | 2819 | 1.950 | 3033 | 2.140 | 3234 |
| 1.765 | 2825 | 1.955 | 3039 | 2.145 | 3239 |
| 1.770 | 2831 | 1.960 | 3044 | 2.150 | 3244 |
| 1.775 | 2836 | 1.965 | 3050 | 2.155 | 3250 |
| 1.780 | 2842 | 1.970 | 3055 | 2.160 | 3255 |
| 1.785 | 2848 | 1.975 | 3061 | 2.165 | 3260 |
| 1.790 | 2854 | 1.980 | 3066 | 2.170 | 3265 |
| 1.795 | 2860 | 1.985 | 3071 | 2.175 | 3270 |
| 1.800 | 2865 | 1.990 | 3077 | | |

1/ Specification requirements begin for this ordered thickness.
2/ Specification requirements end for this ordered thickness.

Note: Tabulated values on either side of the specification requirements are for interpolation of BL(P) requirements on undersize or oversize plates.